

National Aeronautics and
Space Administration

Glenn Research Center
Cleveland, Ohio

The Light Microscopy Module: An On-Orbit Microscope Planned for the Fluids and Combustion Facility on the International Space Station

The Light Microscopy Module (LMM) is planned as a fully remotely controllable on-orbit microscope subrack facility, allowing flexible scheduling and control of fluids and biology experiments within the GRC Fluids and Combustion Facility (FCF) on the International Space Station.

Within the FCF, four fluids physics experiments will utilize an instrument built around a light microscope. These experiments are the "Constrained Vapor Bubble" experiment (Peter C. Wayner of Rensselaer Polytechnic Institute), the "Physics of Hard Spheres Experiment-2" (Paul M. Chaikin of Princeton University), the "Physics of Colloids in Space-2" experiment (David A. Weitz of Harvard University), and the "Low Volume Fraction Colloidal Assembly" experiment (Arjun G. Yodh of the University of Pennsylvania). The first experiment investigates heat conductance in microgravity as a function of liquid volume and heat flow rate to determine, in detail, the transport process characteristics in a curved liquid film. The other three experiments investigate various complementary aspects of the nucleation, growth, structure, and properties of colloidal crystals in microgravity and the effects of micromanipulation upon their properties. Key diagnostic capabilities for meeting the science requirements of the four experiments include video microscopy to observe sample features including basic structures and dynamics, interferometry to

Key diagnostic capabilities include video microscopy, thin film interferometry, laser tweezers, confocal microscopy, and spectrophotometry.

measure vapor bubble thin film thickness, laser tweezers for colloidal particle manipulation and patterning, confocal microscopy to provide enhanced three-dimensional visualization of colloidal structures, and spectrophotometry to measure colloidal crystal photonic properties.

The LMM concept is built around a Leica RXA commercially available upright style microscope. The microscope will house several different objectives, corresponding to magnifications of 10x, 50x, 63x, and 100x. Features of the LMM include cameras, an interchangeable laser tweezer (or confocal) package, tungsten halogen lamps, an auxiliary fluids container (AFC) with gloveports, an experiment transfer module (ETM), and a rotating mounting plate (see figure 1). The multiport imaging head on the top of the microscope provides a motorized slider to select the sensor or sensors to which the images are directed. The rotating mounting plate allows the LMM to be rotated for easy access to the sample area when in a non-operating mode. The AFC prevents liquid droplets (immersion oil or leaking sample material) from escaping into the cabin or into electronics in the FCF. Gloveports allow access to the sample area for cleaning before opening the box for sample platen changeout or reconfiguration. The ETM can accommodate up to 5 sample cell platens, and is configured adjacent to the AFC, which has a pass-through for the samples. The ETM will be loaded with sample platens on the ground, and will provide contained storage until the samples are utilized in the experiment.

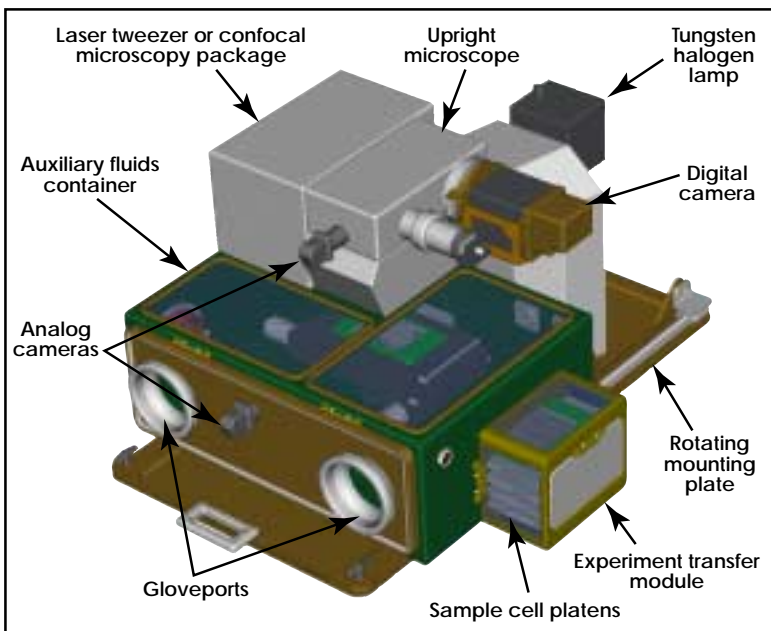


Figure 1. Light Microscopy Module on Rotating Mounting Plate

Laser tweezers will be implemented using a custom-built system based upon a 1064nm Nd:YAG laser, beam focusing optics, and two acousto-optic deflectors to steer the trap within the field of view of the microscope. Laser tweezers simply is the trapping of a colloidal particle using radiation pressure by focusing a laser beam through a high-numerical aperture lens and striking the particle (see figure 2). Tweezers will be employed to displace a particle by one or more lattice constants from its equilibrium position. The tweezers also will be scanned through a fixed array of points across the field of view to induce patterns that are either commensurate or incommensurate with the equilibrium configuration of the colloidal crystal. Laser tweezers also will be used to measure the viscosity of the fluid. A particle is trapped and video images taken as it is translated in an oscillatory fashion through the field of view. The velocity just before the particle falls out of the trap is measured from the video record and, along with the known force and particle diameter, used to calculate the sample dynamic viscosity (or crystal shear modulus).

Confocal microscopy will be implemented using a 532nm frequency-doubled Nd:YAG laser, a Yokogawa Model CSU10 Confocal Scanner, and the 12-bit digital CCD camera. The Yokogawa CSU10 confocal unit employed is a Nipkow disk-based scanner. This method uses a spinning array of apertures and lenses to individually map regions of the sample onto the CCD array, analogous to the raster scan of an electron beam on a cathode ray tube (see figure 3). The rotational speed of the scanner will allow 30 frames per second of confocal images to the CCD camera. Confocal is used on a fluorescent-dyed sample. The crystal three-dimensional structure is reconstructed by assembling the slices with an image analysis program, from which colloidal growth, structure, and dynamics can be measured. The confocal module will be attached and aligned to the side of the LMM using slide rails and will access the sample through an auxiliary port on the Leica RXA. The microscope's reflected light turret will contain a reflecting mirror to direct the light to and from the sample.

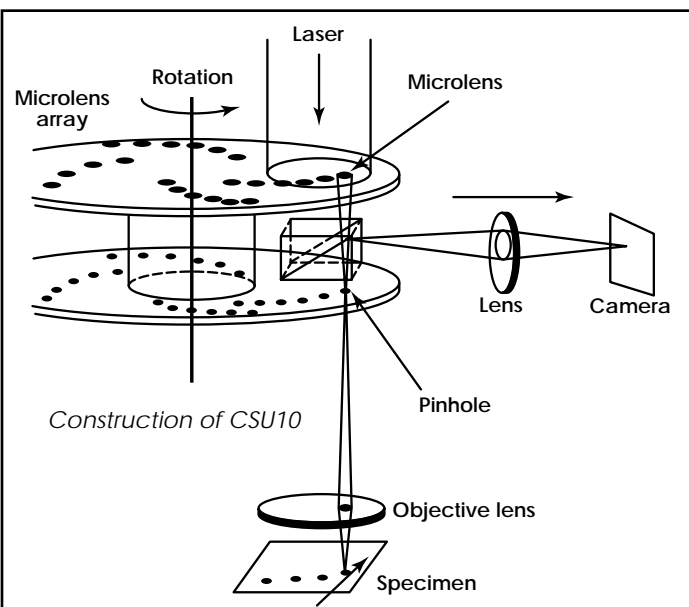


Figure 3. Confocal microscopy: concept and benefits.

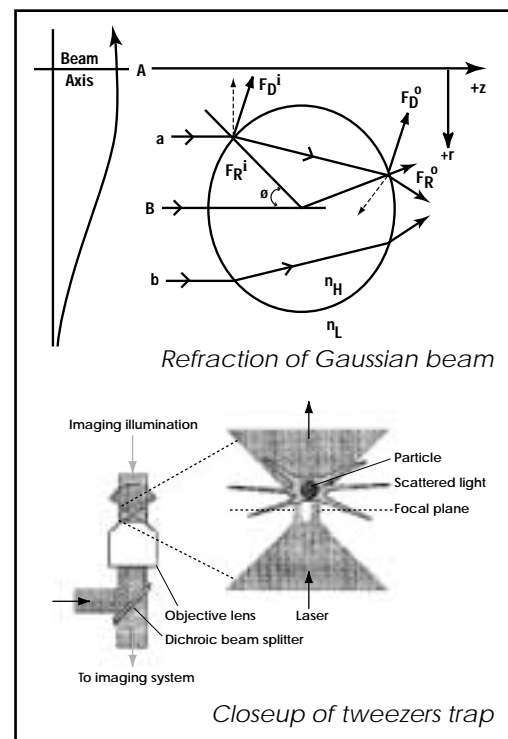


Figure 2. The concept of laser tweezers.

Currently, the LMM project is in the requirements definition and preliminary design phase. A Preliminary Design Review (PDR) will be conducted in mid-2001. The engineering, design, and development of the LMM is being performed under NASA contract NAS3-99155 (Federal Data Corporation).

For further information contact
Michael P. Doherty 216-433-6641
Susan M. Motil 216-433-8589
John H. Snead 216-433-2590
NASA Glenn Research Center
21000 Brookpark Road, Mail Stop 500-102
Cleveland, OH 44135 U.S.A.